The Distribution and Abundance of Nearshore Rocky-Reef Habitats and Fishes in Puget Sound

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Introduction

Rockfishes (*Sebastes* spp.), lingcod (*Ophiodon elongatus*), and kelp greenling (*Hexagrammos decagrammus*) are the most popular bottomfish species targeted by recreational anglers in Puget Sound. In nearshore waters, these species typically inhabit rocky and irregular bottoms, including natural reefs, artificial reefs, shipwrecks, jetties and breakwaters. A large proportion of the recreational bottomfish effort in Puget Sound occurs in the nearshore environment. Thus, in order to provide adequate protection and management for the species and their habitats, it is critical that fishery managers know how much rocky-reef habitat exists and to what extent these areas are utilized.

Since 1993, the Washington Department of Fish and Wildlife (WDFW) has used a video-acoustic technique (VAT) to conduct *in-situ* fish population surveys throughout the inland marine waters of the Washington. The primary objective of the VAT surveys is to provide regional estimates of nearshore rocky-reef fish populations. By using an underwater video camera, it is possible to characterize the habitat observed at each survey station. Thus, a secondary objective of the VAT surveys is to quantify the type and amount of the various habitats encountered. Using geographic information systems (GIS) software, the habitat data collected during these surveys will be used to produce maps of the nearshore rocky-reef habitats within Puget Sound. These habitat data will serve as the basis for future fish population surveys and habitat assessment studies. By identifying the rocky-reef habitats and major concentrations of rocky-reef fishes, smaller scale surveys will be designed to provide more accurate population assessments and produce more detailed maps of individual rocky reefs in Puget Sound.

Methods

Habitat Identification

Prospective rocky-reef habitats within the interior marine waters of the Washington east of the Sekiu River (hereafter referred to as Puget Sound) were initially identified using 1:25,000 and 1:40,000 scale National Ocean Service (NOS) charts, which characterize bottom types and other habitat features. Each survey area, defined as a chart, was categorized into areas likely and not likely to contain reef fish habitat at depths from 0 m to 37 m below mean lower low water (MLLW). Unlikely reef habitat was defined as chart areas with sand or mud on flat, featureless bottom. Potential reef habitat included gravel, rock, boulders, areas of steep relief, sewer outfalls, obstructions, wrecks, and artificial reefs. Identification of potential reef habitat was augmented by knowledge of productive (or formerly productive) fishing areas obtained from WDFW personnel and local anglers. Areas identified as potential habitat were incorporated into a stratified-systematic survey design and digitized on a computer to provide estimates of potential reef area.

Video Survey

For surveys conducted in the San Juan Archipelago (SJA) in 1993 and 1994, potential rocky-reef habitat was partitioned into 1-km segments along the shoreline and stratified by depth into a shallow zone (0–18 fathoms) and a deep zone (19–37 fathoms). Beginning at a random starting point, every fourth station within the SJA was sampled in 1993, with the effort doubled to include every other station in 1994.

In 1994, stations along the Strait of Juan de Fuca (SJF) were established and sampled in a similar manner to those of the SJA. However, the NOS charts were imprecise and included areas where the habitat type was unknown or poorly described. Areas of known reefs were sampled at 0.5-km intervals and areas of unknown habitat were sampled every 1–2 km along the shore. The surveys in this area also included shallow and deep depth strata, as in the SJA surveys.

For the VAT surveys of central and south Puget Sound (CPS and SPS) in 1995 and Hood Canal (HC) and the SJF in 1996, potential reef habitat was stratified on the basis of expected habitat quality. "High" stratum stations included natural reefs, artificial reefs, breakwaters, sewer pipes and other known areas of rockfish and lingcod aggregations. "Medium" stratum stations consisted of habitats with steep slopes, kelp beds, cobble bottoms, or other potential habitats. Stations in the "Low" stratum included areas where the habitat type was unknown but offered some possible rockfish or lingcod habitat. High-stratum stations were defined around a grid 0.19 km square (= 0.036 km^2), and Medium-stratum stations were defined around a square grid of 0.39 km (= 0.152 km^2). Low-stratum stations were defined either as a 1.0-km station along the shore similar to the station pattern in the SJA, or in the case of offshore banks and reefs, around a square grid of 0.77 km (= 0.592 km^2).

For surveys conducted in 1993 and 1994, all camera deployments were made as close to the geographic center of the station as possible, with target depths of 7 fathoms and 15 fathoms in the shallow and deep strata, respectively. No depth strata were used in 1995 and 1996; instead, camera deployments were made at a pre-selected random depth within each station square.

The video platform for all surveys consisted of a tripod, 1.5 m in height, constructed from 2 cm diameter steel reinforcing rods (rebar). Weights were attached to the bottom of the platform to improve stability during high current (<1.5 knots) deployments. The total weight of the camera platform and attached weights was approximately 75 kg. A Remote Ocean System PT-25 pan and tilt motor was suspended from the apex of the tripod to which a Deep Sea Power and Light underwater black-and-white television camera and light was attached. A 2-cm kevlar line attached to the platform was used to raise and lower the cage from a support vessel. A 2.5-cm multistrand underwater electrical cable was attached to the camera, light, and motor and extended to the vessel where it was attached to a Remote Ocean System controller.

The Research Vessel *R/V Molluscan*, a 12-m long, diesel-powered, displacement-hull vessel with a draft of 1.7 m was used to deploy the video platform during all surveys. A hydraulic deck winch mounted on the aft deck was used to deploy the kevlar line through a gantry mounted around a 1.5-m port in the transom. The gantry allowed the lift point to clear the camera platform from the deck and suspend the camera platform approximately 2 m away from the stern. The electrical cable was deployed and retrieved by hand, and was stacked on deck near the transom. For surveys conducted in 1993, 1994, and 1995, the support vessel was equipped with a Magellan Differential Geographic Positioning system (DGPS). This system was upgraded to a Northstar 951 DX DGPS chart plotter for the 1996 survey, providing more accurate geographic position fixes and allowing for more efficient survey planning and execution. Other equipment used during the surveys included a video depth sounder, radar, and LORAN.

The motor, camera, and light were remotely controlled by an operator aboard the *R/V Molluscan*. A minimum of two 36o_ sweeps of the viewing plane were conducted during each camera deployment. During each sweep, the camera was tilted up and down to screen the entire field surrounding the platform within 2 m of the bottom. Each sweep lasted about two minutes and three sweeps were usually attempted at each deployment. Total deployment time, including descent and ascent, ranged from seven to 12 minutes, depending upon the depth of deployment. When current or boating conditions were severe, only two camera sweeps were conducted, but at least two sweeps were required for the deployment to be valid. When the camera platform was overturned or other conditions prevented two successful sweeps, the platform was redeployed for another trial. All activities including deployment, platform positioning, camera sweeps, and retrieval were recorded on Hi-8-mm video tape with a Sony EVS 3000 video cassette recorder. Videotapes were labeled and archived for laboratory analysis.

In the laboratory, VAT survey tapes were reviewed and the fishes and commercially important invertebrate species were identified and enumerated for each camera sweep. Only fishes observed within 2 m of the bottom were counted. An estimate of the visible range of the camera was made for each deployment. Visibility estimates were based on scuba observations and measurements of distance, camera angle, and water clarity. Habitat information collected from the videotape included dominant and sub-dominant substrate, vertical relief, habitat complexity, and dominant and sub-dominant biological cover. Substrates were divided into four major categories, with the dominant substrate being that which comprised the majority of the area viewed by the camera. If more than two substrate types were present, only the two most abundant types were recorded in the database. Rocky-reef habitat included bedrock, boulder, and hardpan (e.g., clay, sandstone) substrates. Cobble and gravel substrates were classified as coarse grain habitats, with sand and mud bottoms comprising fine grain habitats. The "artificial" category included artificial reefs composed of tires, concrete rubble, and/or quarry rock, shipwrecks, and other sunken man-made structures (e.g., docks, pilings, log rafts, sewer pipes, etc.) Vertical relief was determined based on the relative elevation of the surrounding habitat to the camera. Habitat complexity was a subjective measure, and was visually estimated as the amount of crevice space 10 cm or greater within the survey plot.

In 1993 and 1994, the water surface area of rocky-reef habitat within each survey area was estimated by multiplying the proportion of stations containing rocky-reef substrate by the total survey area. At selected stations in 1995 and 1996, particularly small natural reefs, artificial reefs, shipwrecks, and sewer pipes, the approximate boundaries of the observed feature were plotted using the *R/V Molluscan*'s bottom sounder and DGPS. These boundaries were recorded in the GIS database and the area calculated. For the remaining stations, the area encompassed by the grid square was used as the default station area. The total amount of rocky-reef habitat was then calculated by summing the areas of all stations where rocky-reef substrate was observed.

Density estimates for each taxon were made by dividing the number of individuals (C) for each taxon observed during the last valid camera sweep by the area viewed during the deployment. The viewing area (a) of the deployment was determined by using the estimated visibility (V) as the radius in the area of a circle. For each taxon, density (f) was estimated as:

$$f = \frac{C}{a} = \frac{C}{(\pi V^2)}.$$

For each nautical chart or management region, representing an independent survey area, the stratum estimates of video fish density were averaged among stations and variances computed for the stratified systematic sample (Shaeffer et al., 1986). Where f_{ij} is the fish density observation for the i-th of n stations in the j-th stratum, A_j is the area of the j-th stratum, N_j is the species population estimate of the j-th stratum, and $Var(N_j)$ is the population variance of the population estimate of the j-th stratum:

Population estimate: $$N_j = A_j \bar{f}_j = A_j \sum_{i=1}^{n=i} \frac{f_{ij}}{n}$$

Population variance: $$Var(N_j) = A^2 Var(\bar{f}_j) = A^2 \sum_{i=1}^{i=n} \frac{(f_{ij} - \bar{f}_j)^2}{(n-1)}$$

Results

From 1993 to 1996, a total of 2,008 VAT camera deployments were accomplished in the six Groundfish Management Regions (GMRs) surveyed in Puget Sound (Table 1, Figure 1). Coarse grain and fine grain substrates were commonly encountered during all surveys. Stations with dominant rocky-reef substrates included boulder fields, scoured bedrock or clay bank walls, rocky ledges, and bedrock outcroppings. At stations where rocky-reef substrates were sub-dominant, the habitat consisted largely of gravel or sand bottoms with widely scattered boulders or small bedrock ridges.

In the SJA, nearly 55% of the stations surveyed contained rocky-reef habitat as either the dominant or sub-dominant substrate, resulting in an estimated rocky-reef area of 111.8 km^2 (Table 2). Rocky-reef habitat in the SJF was estimated to be 95.3 km^2 in 1994, and comprised 19% of the total area surveyed. In 1996, the area of rocky-reef habitat in the SJF was estimated to be 34.4 km^2, or about 36% of the total survey area. Rocky-reef habitat in central and south Puget Sound made up 18% of the survey area in these regions, with an estimated area of 9.9 km^2, about 75% of which was in the CPS region. Nearshore rocky-reef habitat was sparse in the GB and HC regions, with estimates of 2.7 km^2 and 1.0 km^2, respectively.

Table 1. Number of camera deployments by region and year for WDFW VAT surveys.

Region and Year	Number of camera deployments
San Juan Archipelago 1993	228
San Juan Archipelago 1994	407
Strait of Juan de Fuca 1994	194
Central Puget Sound 1995	367
South Puget Sound 1995	177
Gulf-Bellingham 1995	50
Strait of Juan de Fuca 1996	461
Hood Canal 1996	124

The area estimates of rocky-reef habitat were lower in most regions when only the dominant substrate was used for the area calculation. The amount of rocky-reef habitat in the SJA dropped over 30% to 76.5 km^2, while the 1994 estimate for the SJF was reduced over 80% to 13.6 km^2. Rocky-reef area estimates were 50% to 80% lower in the other regions except HC, which did not change. Artificial substrates were observed in four of the regions, but made up only a small proportion of the total survey areas (Table 2).

Table 2. Estimated area (km^2) of all habitat types sampled during the nearshore VAT surveys.

	Substrate area (km^2)				
Region/Year	Rocky-reef total	Rocky-reef dominant	Coarse	Fine	Artificial
SJA 1993–4	111.8	76.5	36.0	50.6	---
SJF 1994	95.3	13.6	132.2	274.6	---
CPS 1995	7.6	2.6	12.5	18.8	0.4
SPS 1995	2.3	1.2	4.7	9.5	0.6
GB 1995	2.7	0.6	0.2	4.7	---
SJF 1996	34.4	7.5	28.0	33.7	0.3
HC 1996	1.0	1.0	1.4	11.9	0.2

Frequencies of occurrence for the target species varied by region, but never exceeded 18% (Figure 2). Copper rockfish *Sebastes caurinus* were the most commonly encountered target species, with the exception of the SJA in 1993 and the SJF in 1994. Quillback rockfish *S. maliger* occurred at about one-fourth to one-third the frequency of copper rockfish except in the CPS region, where they were observed in similar frequencies. Lingcod *Ophiodon elongatus* were observed on 1%–4% of all camera deployments, with the highest frequencies seen in the SJA in 1994 and in the SPS in 1995. Frequencies of occurrence of kelp greenling *Hexagrammos decagrammus* were similar to those for lingcod, ranging from 1% in SPS and HC to 10% in the SJA (1993). Black rockfish *S. melanops* were rarely seen, although when observed, they usually occurred in schools of 10 to 40 or more fish. The highest encounter rates were in the SJF in 1996 (3% FO), with the majority of occurrences in kelp beds (*Nereocystis leutkeana* and *Pterygophora* spp.) None of the primary target species were observed in the Gulf-Bellingham region.

Most observations of the target species occurred at stations where rocky substrates were present (either as the dominant or sub-dominant substrate.) For example, rocky-reef habitat was present at 94% of the stations with copper rockfish and at 74% of the stations with lingcod. However, copper rockfish and lingcod were observed at less than 20% and 5%, respectively, of all stations containing rocky-reef substrates. By region, copper rockfish were present at 3% of the rocky-reef stations in the SJF in 1994 and at 65% of all rocky-reef stations in the HC region (Figure 3). In the other regions, frequencies of

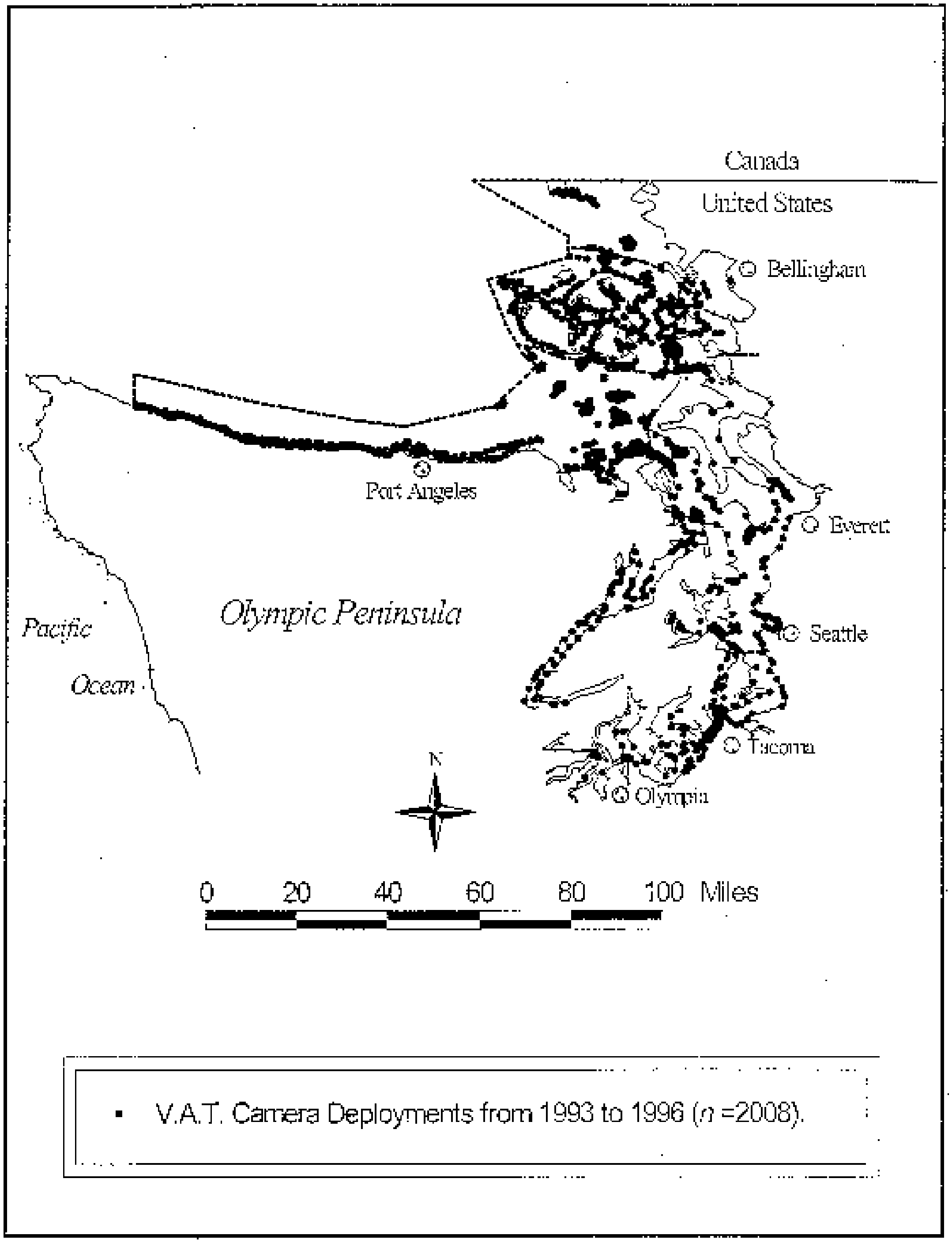

Figure 1. Locations of VAT camera deployment during nearshore VAT surveys, 1993–1996.

occurrence ranged from 11% to 27%. Copper rockfish were relatively common on artificial substrates in three of the regions, occurring on 33% to 43% of these substrates. In the CPS, SPS, and HC regions, about half of the artificial substrate stations sampled were reef structures constructed for the purpose of attracting fish. In the SJF (1996), the artificial substrates sampled included shipwrecks, ballast rock mounds, and marina breakwaters. Copper rockfish were less common on artificial substrates in the SPS region (18% FO), which consisted mainly of sewer discharge pipes and tire reefs.

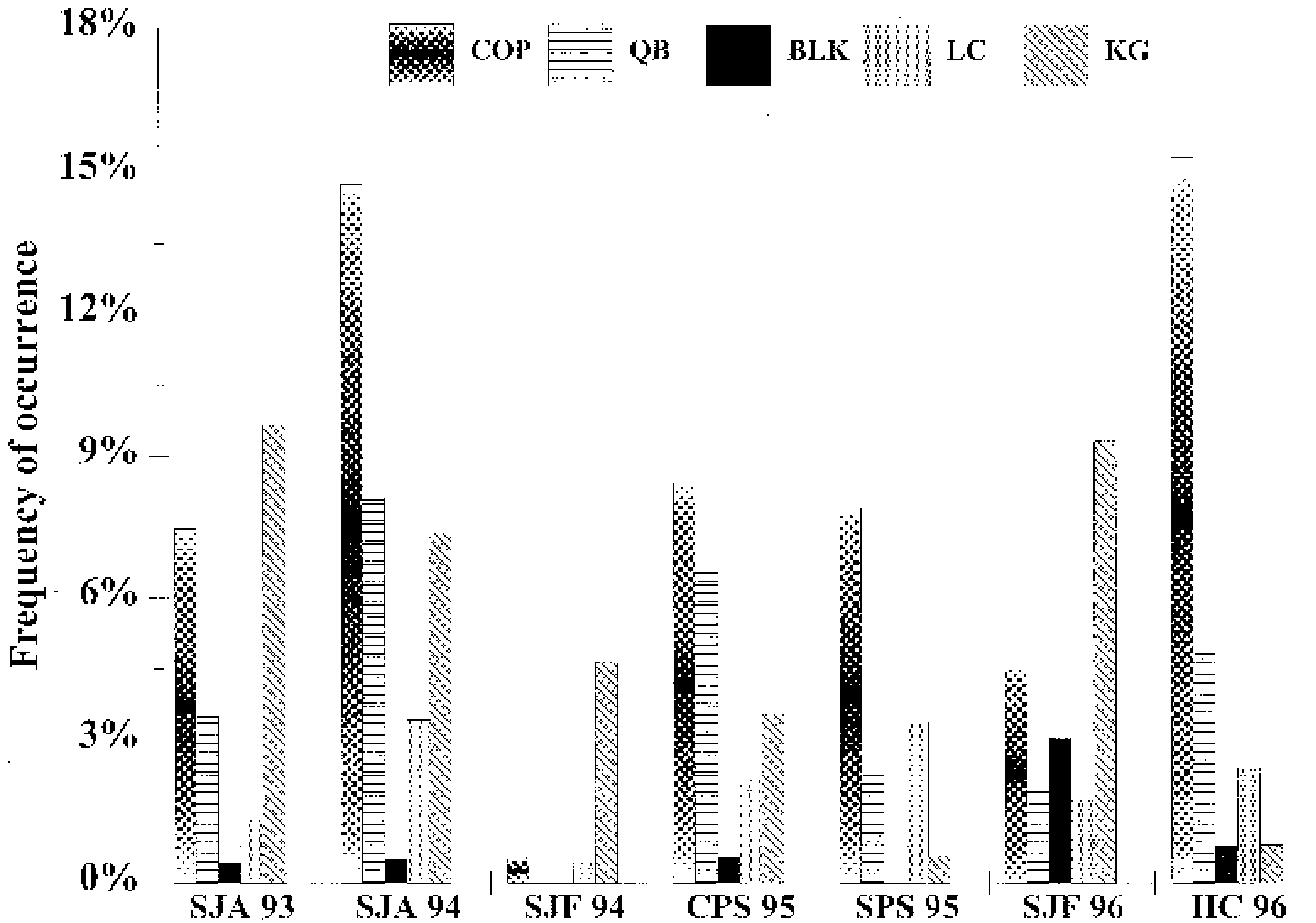

Figure 2. Frequency of occurrence of five bottomfish species observed during the nearshore VAT surveys by region. (COP = copper rockfish, QB = quillback rockfish, BLK = black rockfish, LC = lingcod, KG = kelp greenling).

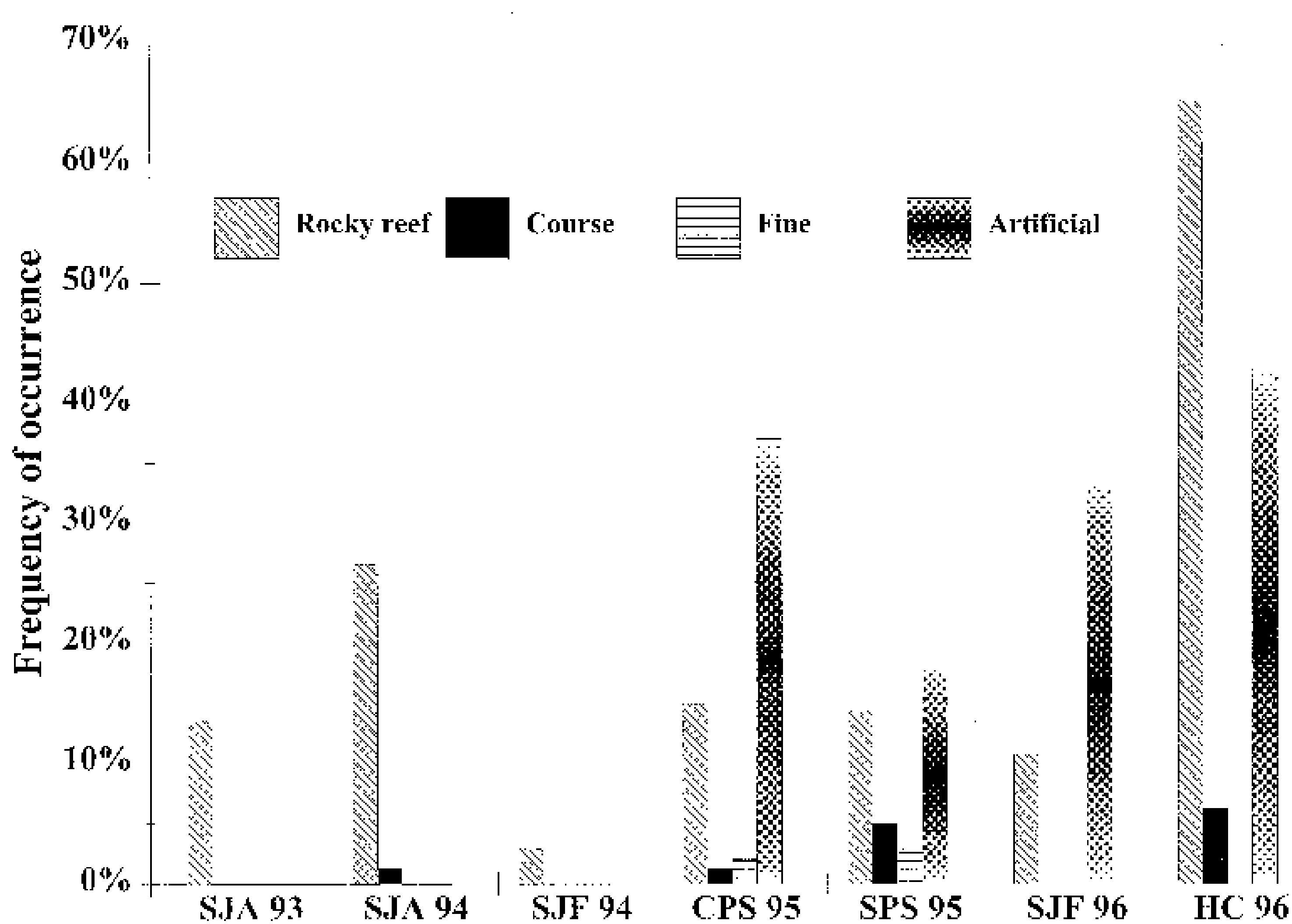

Figure 3. Frequency of occurrence of copper rockfish by habitat type and region.

Population estimates for copper rockfish ranged from 87,000 fish in HC to 3.6 million fish in the SJA (Table 3). About 500,000 copper rockfish were estimated from the 1994 survey of the SJF, but that estimate was reduced to 0.1 million fish in the 1996 survey. Estimates for the CPS and SPS were similar, with just over 100,000 copper rockfish in each region. Quillback rockfish were most abundant in the SJA (1994, 1.9 million fish) and substantially lower in the other regions. Unlike the other regions, quillback rockfish were more abundant than copper rockfish in CPS, with an estimated 202,000 fish. Lingcod were most abundant in the SJA, with approximately 313,000 fish inhabiting nearshore reefs. Lingcod abundance differed in other regions and was lowest in HC, with an estimated 16,000 fish. Black rockfish abundance was very low in all regions except the SJF (1996), where the nearshore population was estimated to be about 434,000 fish. Kelp greenling also showed differing population estimates among regions, but were most abundant in the SJF (1996), with about 363,000 fish in this region.

Coefficients of variation (C.V.) (weighted by chart for each region) were highly variable. Except for the SJF in 1996, copper rockfish C.V.'s were relatively low, ranging from 23.1% to 41.9% (Table 3). In the SJA, copper rockfish C.V.'s declined from 35.6% in 1993 to 23.1% in 1994 when sampling effort was essentially doubled. Quillback rockfish C.V.'s were slightly higher than for copper rockfish, and showed a similar decline in the SJA, dropping from 45.1% in 1993 to 32% in 1994. Black rockfish were only observed in the SJA, SJF, and CPS regions, and had C.V.'s between 51% and 73%. Lingcod C.V.'s were lowest in the SJA (1994), CPS and SPS regions, from 31.6% and 45.5%, while C.V.'s in the other regions were between 56% and 100%. Kelp greenling were common in the SJA, SJF, and CPS regions, with C.V.'s ranging from 21% to 50%. Kelp greenling were observed at only a single station in both the SPS and HC regions, with corresponding C.V.'s of 100%.

Table 3. Minimum population estimates (in thousands of fish) and coefficients of variation for five rocky-reef species from the video survey.

	Species									
	Copper rockfish		Quillback rockfish		Black rockfish		Lingcod		Kelp greenling	
Region	# fish	%C.V.	# fish	%C.V.	# fish	%C.V.	# fish	%C.V.	# fish	%C.V.
SJA 1993	2,144.2	(35.6)	723.0	(45.1)	0	(---)	304.7	(58.4)	772.0	(27.5)
SJA 1994	3,639.5	(23.1)	1,850.1	(32.0)	28.1	(70.8)	312.7	(31.6)	576.0	(20.7)
SJF 1994	532.0	(100)	0	(---)	0	(---)	127.0	(100)	1,231.4	(49.0)
CPS 1995	109.1	(20.8)	202.1	(40.9)	5.6	(72.9)	17.6	(47.8)	25.9	(32.0)
SPS 1995	101.0	(41.9)	15.1	(66.0)	0	(---)	10.2	(45.5)	6.3	(100)
GB 1995	0	(---)	0	(---)	0	(---)	0	(---)	0	(---)
SJF 1996	100.9	(29.9)	80.8	(51.0)	433.7	(51.3)	69.9	(56.4)	362.9	(26.9)
HC 1996	86.5	(25.1)	15.8	(46.2)	0	(---)	2.0	(69.8)	1.8	(100)

Discussion

Between 1993 and 1996, more than 2,000 camera deployments were made in the nearshore (0 to –37 m MLLW) waters and shallow offshore reefs of six Puget Sound groundfish management regions. Despite attempts to eliminate non-rocky-reef habitat from the sampling frame prior to each survey, large amounts of fine grain and coarse grain sediments were sampled relative to the amount of rocky-reef habitat encountered. The amount of rocky-reef habitat was greatest in the SJA and was estimated to be about 112 km^2 (sea surface area). However, because substrate area was calculated based only on the proportion of stations containing a particular substrate type, and not on the actual station areas (which were unknown), no compensation was made for the generally larger surface areas of coarse-grain and fine-grain stations due to the shallower bottom slopes associated with these stations. As a result, the amount of rocky-reef habitat in the SJA may have been overestimated. In the future, individual stations will be digitized on the computer in order to calculate more accurate rocky-reef habitat estimates.

The amount of rocky-reef habitat in the SJF in 1994 may also have been overestimated, for the same reason cited for the SJA. As seen in Table 1, the estimate of total rocky-reef habitat in 1996 was over 60% less than in 1994. This reduction can be attributed to the change in survey design between years, which, due to the increased sampling rate and smaller station sizes, likely resulted in more accurate substrate area estimates.

Rocky-reef habitat in the CPS, SPS, and HC regions is limited, with a combined total of only 11 km^2. Most of the habitat sampled in these regions consisted of fine grain sediments, although a considerable amount of coarse grain habitat was sampled in the CPS. Due to the large area comprised by these regions and the limited amount of sampling time available for the video surveys, it is highly likely that more rocky-reef habitat exists than was identified. For example, several popular scuba diving sites in HC are known to contain rocky-reef habitat, but were not sampled during the 1995 VAT survey. Although the size of these reefs is limited, they do appear to support localized concentrations of rocky-reef fishes, mainly rockfish and lingcod (T. Parra, WDFW, pers. Comm.). These reefs will be included in subsequent surveys of the region, but given their limited size, will likely not result in a significantly greater estimate of rocky-reef habitat.

Although the majority of the target species were observed in association with rocky-reef substrates, frequencies of occurrence were considered to be low. Depending upon the region, copper rockfish were only observed at 3% to 27% of the rocky-reef stations sampled (except in the HC). Differences in habitat quality at the rocky-reef stations may account for these relatively low encounter rates. Matthews (1989) found that densities of adult rockfishes (*Sebastes* spp.) in CPS varied between reef types and were highest on high-relief reefs. Further, we have observed that high-relief/high-complexity habitats (e.g., boulder fields) are preferred by copper and quillback rockfish. Of the rocky-reef stations we surveyed, nearly 75% were lacking in relief, complexity, or both, and less than 10% of these stations had rockfish or lingcod present. At almost half of the stations where rocky-reef substrate was dominant, the habitat consisted of low-relief and/or low-complexity bedrock reefs and walls. At the majority of stations where rocky-reef substrate was sub-dominant, the habitat consisted of sand, cobble, or gravel bottoms with widely scattered boulders. Although some of the larger boulders offered vertical relief in excess of 1.5 m, the expanse between boulders was large, resulting in low-complexity environments that generally were devoid of fish.

The relatively high frequency of occurrence of copper rockfish on artificial substrates was not surprising (Figure 2). Artificial reefs are colonized quickly by rockfish and other rocky-reef species within a few days or months of construction (Buckley and Hueckel, 1985). Shipwrecks also had concentrations of several target species. At all of the larger wrecks (>10 m length, 2+ m vertical relief), we found 20 or more rockfish present, including copper, quillback, black, and blue rockfish. Based on the results of a study conducted on a sunken dry dock in Puget Sound (Palsson and Pacunski, 1995), it is highly likely that rockfish inhabiting these sites may be permanent residents until caught in the recreational fishery.

Population estimates for the target bottomfish species were highest in the SJA and SJF regions. This result was expected given the much greater amount of rocky-reef habitat in these regions. In the other regions, where rocky-reef habitat was limited, population estimates were substantially lower. Some of our unpublished experiments have shown that the VAT camera misses up to 30% of fish in higher-complexity habitats because fish are hiding or obscured by rocks. This problem may be particularly exacerbated for lingcod, which are more difficult to detect than rockfish, due to their more camouflaged appearance. Consequently, since over 40% of fish observations occurred in higher-relief and/or higher-complexity habitats, population estimates for the target species represent minimum estimates only.

Coefficients of variation for copper rockfish and kelp greenling were relatively low in most regions, indicating that the VAT is a practical method for assessing shallow water populations of these species. Quillback rockfish, which tend to be distributed at greater depths than copper rockfish, and lingcod, which were often difficult to detect with the black-and-white camera, were less common in the VAT surveys. Consequently, C.V.'s for these species were higher and more variable than for copper rockfish, but were still within acceptable limits for a population survey. Black rockfish were seldom seen in the VAT surveys, mainly because we did not sample the very nearshore kelp beds in which this species tends to occur. As a result, C.V.'s for two of the regions where black rockfish were encountered were very high (>70%). However, more black rockfish were observed in the SJF in 1996 due to the change in survey design, which allowed for a higher rate of sampling in kelp beds, thereby reducing the C.V. to a more acceptable level.

The target species of the VAT surveys are not constrained to the shallow depths that we sampled. Copper and quillback rockfish have been observed at depths of 140 m, and show similar habitat affinities to those we observed (Richards, 1986; Murie et al., 1993). Similarly, lingcod have been observed at depths up to 126 m utilizing complex habitats as nesting sites (O'Connell, 1993). Puget Sound reaches depths of over 100 fathoms (180 m), and it is known from WDFW trawl surveys that rockfish and lingcod inhabit these depths. Since little recreational fishing effort occurs at depths greater than 60 m, lingcod and rockfish populations at these depths may be significantly larger than in nearshore areas. Improvements to the VAT system will enable us to assess fish populations at greater depths and to characterize more habitat. A recently acquired laser scaling system will allow us to measure fish and objects in future surveys, resulting in age-structured models of the populations and better habitat characterizations. Additionally, image enhancement software will be used to aid in identifying and measuring fish from the videotapes, and should reduce the number of unidentified rockfish observed, thereby improving species population estimates. Future video surveys, especially those conducted at greater depths, may prove challenging, but should provide fishery scientists with valuable data and information concerning Puget Sound bottomfish populations and their habitat associations.

Results obtained from these and future surveys will be used to improve the management of the recreational bottomfish fishery in Puget Sound. Also, these data may be useful in defining "essential fish habitat" as required by the Magnuson-Stevens Fisheries Conservation and Management Act. Because many of the bottomfish stocks (i.e., species) in Puget Sound are characterized by the WDFW as below average or critical (Palsson et. al., 1997; West, 1997), data from these surveys may also be used to identify sites that could be incorporated into a system of "marine protected areas" for the protection and enhancement of these species.

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